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POPULATION DYNAMIC AND EXPLOITATION RATE OF THE BLUE SWIMMING CRAB (*Portunus pelagicus*) IN THE KENDARI BAY WATERS

Ali Suman*[1], Ap'idatul Hasanah[1], Khairul Amri[1], Andina Ramadhani Putri Pane[1] and Pratiwi Lestari[1]
Research Institute for Marine Fisheries, Ministry for Marine Affairs and Fisheries, Jl. Raya Bogor No. 507, Nanggewer Mekar, Cibinong, Bogor, Jawa Barat 16912, Indonesia
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ABSTRACT

Kendari Bay waters consitute a potential blue swimming crab (BSC) fishing ground in WPP NRI 714 (the Banda Sea). The intensive fishing activities have been increasing from year to year that will disturb resource sustainability. Therefore, an alternative sustainable management is advisable. The purpose of this research was to examine the population dynamics and exploitation rate of BSC in the Kendari Bay waters conducted between January and November 2016. The results show the isometric of BSC growth pattern and balance of male and female ratio. The length at first capture (L_c) of BSC was 116.65 mm (carapace width), smaller than the length at first maturity (L_m) at 119.7 mm (carapace width). The von Bertalanffy growth equation for the blue swimming crab was $L(t) = 182.0[1-e^{-0.91\,(t-0)}]$ and the fishing mortality rate (F) was higher than the natural mortality rate (M). The blue swimming crab exploitation rate calculated BSC from Kendari Bay has exceeded the optimum rate of 0.73 per year and is indicating a category "overfishing". Therefore, to maintain the BSC stock sustainability, a management measure is needed to reduce the current fishing effort of approximately 46 % from the current effort and regulation of net mesh size.

Keywords: Blue swimming crab; population dynamics; exploitation rate; Kendari Bay; Fishing Management Area (FMA) 714

INTRODUCTION

Kendari Bay waters are one of the potential fishing grounds of the blue swimming crab (BSC) in FMA 714 (Banda Sea). Crab resource has been utilized from these waters since long time ago, but the utilization was commercially began in 2000 with the development of fishing gears to capture blue swimming crabs, namely trap and bottom gillnet. Since then, the BSC exploitation has been developed to be very intensive due to the growing demand and the growing fishing fleets and fishermen, resulting annual catch of crabs to increase continously (RIMF, 2016).

Even though the BSC resource is a renewable resource, the unlimited increase in fishing will cause the depletion of its stock. In fact, the fishing intensity of BSC in the Kendari Bay is very high, the fishing of BSC is conducted every day of the year. There is a growing concern that the intensive exploitation of BSC will threaten its resource sustainability. The actual condition should be left, so it needs an effort to manage the exploitation of BSC resource in a better way in order to keep the remaining resources to be used as capital of stock recovery in term of sustainable utilization.

To maintain the sustainable utilization of blue swimming crab resources in Kendari Bay and surrounding waters, the management measures must be done based on knowledge of population dynamic and exploitation rate, enabling to determine the stock status. Therefore, the exploitation pattern of BSC resources in Kendari Bay and surrounding waters would ensure the sustainability of the resources in the long term (FAO, 1995). In this perspective, the current paper discusses the population dynamics and exploitation rate of BSC in the Kendari Bay waters and would provide expected information to use for BSC resource management and as reference for further research.

MATERIALS AND METHODS

Total of 1,643 BSC samples were taken by random sampling from catches landed by fishermen site

correspondence author:
e-mail: alisuman_62@yahoo.com

between January and November 2016 in Kendari Bay waters (Figure 1). Then, samples were measured for carapace width (CW), weight (gram), sex (male or female), and gonad maturity stage.

The relationship between the blue swimming crab length and weight follows the cubic law (Bal & Rao,1984; King, 1995): W = aL^b, with W as the weight (gram); L as the BSC carapace width (mm) and a,b as constants. The sex ratio was calculated by comparing the number of male and female and analyzed to know whether the sex ratio is balance or not by using the Chi-square test (Walpole, 1993).

Figure 1. Fishing ground of BSC (*Portunus pelagicus*) in Kendari Bay ($3^0 58'$S"NL-$112^0 33'$E" EL to $3^0 58'$S"NL-$112^0 34'$E"EL).

The calculation of the length at first capture (L_c) was done using the Sparre & Venema (1992)'s equation as follows:

$$S_L = \frac{1}{1+\exp(s1 - s2\; x\; c)};\; In\left[\left(\frac{1}{S_L}\right)-1\right] = S_1 - S_2\; x\; L \quad \text{...... (1)}$$

where SL is the logistic curve and S1 and S2 are constants in the logistic curve equation.

The length at first maturity (L_m) was calculated by entering the carapace width value and P_{Lm} to the logistic function graph (King, 1995), using the following equation:

$$P_{Lm} = \frac{1}{1+\exp(\alpha l + b)} \quad \text{.................................... (2)}$$

The growth parameters (K and Loo) were estimated after the von Bertalanffy growth model (Sparre & Venema, 1992):

$$L_t = L\infty\left[1 - e^{-k(t-to)}\right] \quad \text{.................................... (3)}$$

where, L_t as the blue swimming crab's carapace width when at age t, L_∞ the theoretical maximum carapace width (asymptotic carapace width), K as the growth coefficient and t_0 as the theoretical age when the blue swimming crab's carapace width was zero.

The growth parameter (K and Loo) were analyzed after the ELEFAN I program in the FISAT II program (Gayanilo *et al*., 2005).

The total mortality (Z) was estimated by using the length converted catch curve method in the FISAT II program package (Pauly, 1983; Gayanilo *et al.*, 2005). The estimation of the natural mortality rate (M) was done using the Pauly *et al.* (1984) equation with the addition of the average temperature:

$$\text{Log (M)} = -0.0066 - 0.279 \log (L_\infty) + 0.6543 \log (K) + 0.4634 \log (T) \quad \text{............................ (4)}$$

The fishing mortality rate (F) and exploitation rate (E) were estimated using the Sparre & Venema (1992) equation:

$$F = Z - M \text{ and } E = \frac{F}{Z} \quad \text{..................................... (5)}$$

RESULTS AND DISCUSSION
Results

The Relationship Between Length-Weight and Sex Ratio

The growth pattern of male and female BSC was isometric (Table 1), indicating both carapace and weight of BSC growing in balance.

The sex ratio of BSC was 1.0 : 1.1 or balance condition (significant with chi-square test) This indicates the renewal population of BSC in these waters would be still adequate.

The Length at First Capture (Lc) and The Length At First Maturity (L_m)

From the analysis using a logistic curve of BSC, it shows that the Lc was found at a carapace width (CW) of 116.65 mm (Figure 2).

Meanwhile, the BSC analyzed using a logistic function reaching at first gonad maturity (L_m) was in average at 119.7 mm (carapace width), as seen in Figure 3.

Table 1. Length- weight relationship of blue swimming crab (*Portunus pelagicus*) in Kendari Bay waters

Sex	n	r^2	a	b	Growth pattern
Male	784	0.92	0.0555	3.31	isometric
Female	859	0.89	0.0855	2.86	isometric

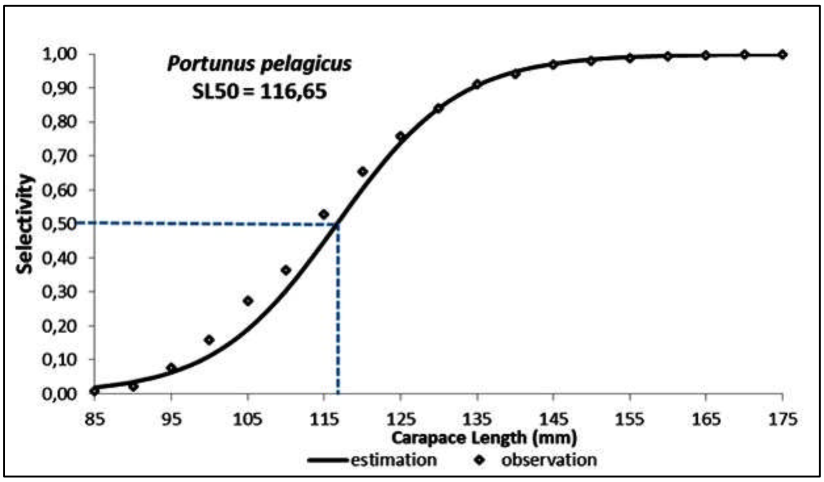

Figure 2. Length at first capture of blue swimming crab (*P. pelagicus*) in Kendari Bay and surrounding waters.

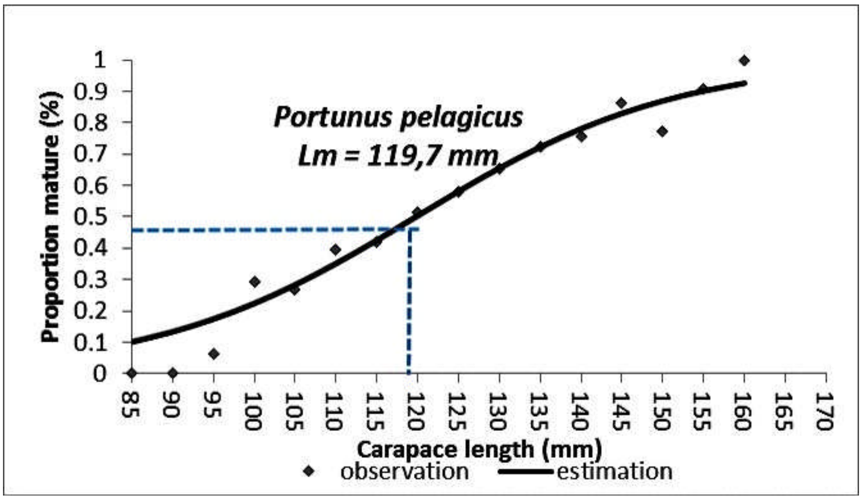

Figure 3. Length at first maturity (Lm) of blue swimming crab (*Portunus pelagicus*) in Kendari Bay waters.

Growth parameter

The best fits of the blue swimming crab carapace width distribution analyzed using the ELEFAN I method, can identify the significant difference in new cohorts that emerge every month (Figure 4). The growth rate (K) of BSC was 0.91 per year and its maximum carapace width (L_∞) was calculted about 182 mm.

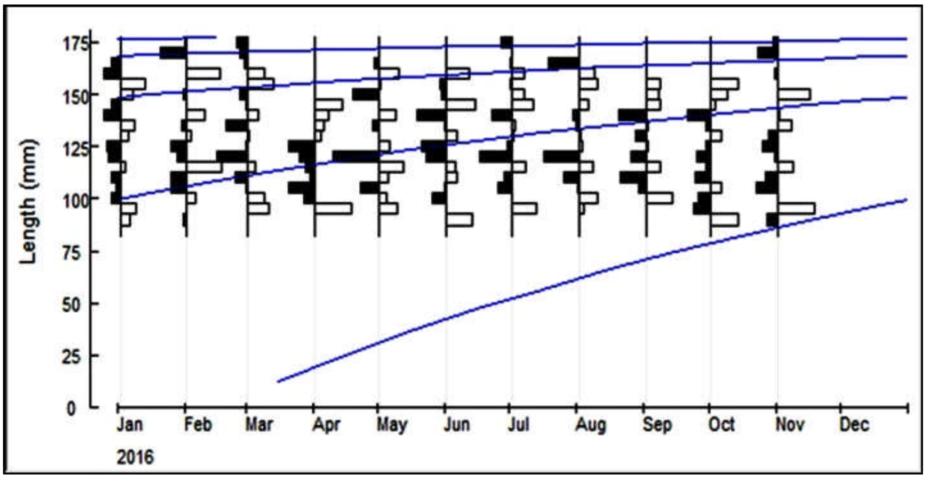

Figure 4. Von Bertalanffy growth curve of blue swimming crab (*Portunus pelagicus*) in Kendari Bay waters.

Exploitation Rate

The total mortality rate (Z) of BSC was 3.99 per year (Figure 5). Meanwhile, its natural mortality rate (M) was 1.07 per year and mortality rate due to the fishing (F) was 2.92 per year.

The combination of F and Z values permetted to calculate the exploitation rate (E) that was 0.73 per year. The value of E value was representing BSC utilization rate in the Kendari Bay waters that reached 146%, means that the exploitation of BSC is already in overfishing condition.

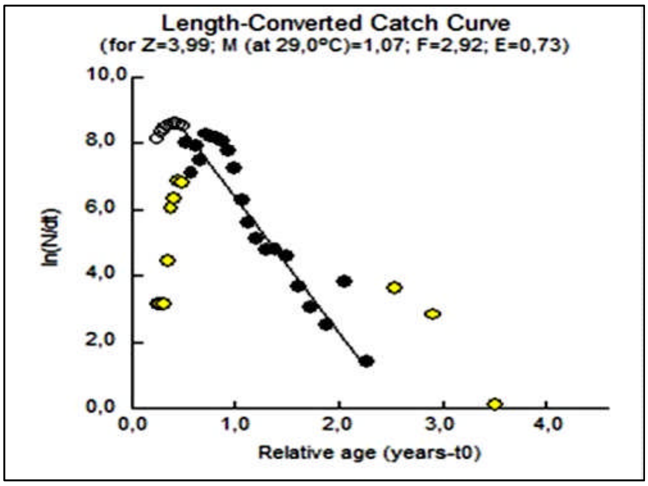

Figure 5. Length-converted catch curve of blue swimming crab (*Portunus pelagicus*) in Kendari Bay waters.

Discussion

The growth pattern of male and female of blue swimming crabs in the Kendari bay was isometric, showing the balance of growth of the carapace width and weight. This study result is in line with the growth pattern of male BSC in the East Lampung waters, but different for the growth of the females' which was positive allometric (Damora & Nurdin, 2016). A positive allometric growth pattern was also reported for BSC of Pati waters (Ernawati *et al*., 2014). According to Bagenal (1978), factors that may cause the difference in the value of b, besides the difference in species, are the number of fish and size variations observed, the fish's development stage, sex, and environmental factors. Sparre & Venema (1992) also stated that the difference in growth characteristics is influenced by many factors, such as: season, temperature, salinity, availability and quality of food, sex, and gonad maturity level.

Sex ratio of male and females BSC was balance (1.0 : 1.1). The balance of sex ratio indicates that the recovery of BSC population in these waters will not disturb (Naamin, 1984). This finding is similar to that reported for BSC from South East Sulawesi waters (Sara *et al*., 2016). A different phenomenon was discovered in the waters of Bone, where the sex ratio of male and female blue swimming crabs was imbalance (Kembaren & Ernawati, 2012). This phenomenon possible occurred due to the different analysis of male and female sex ratios done prior to and during spawning season (Nikolsky 1963).

The length at first maturity (L_m) of the blue swimming crabs in Kendari Bay was 119.7 mm of width carapace. The L_m value found in this study is slightly higher than those reported for BSC of South East Sulawesi and East Lampung waters, that ranged between 108.2 and 113.5 mmCW (Damora & Nurdin, 2016; Sara *et al*., 2016). Nikolsky (1963) stated that L_m value is influenced by some factors, such as: depth and type of habitat in association with food availability, temperature, and light. According to Sivakami *et al*. (2001), the difference in L_m value for each fish is caused by the difference size of samples collected, the maximum and minimum length, and frequency of fish that are gonad-mature. So allegedly that the availability of food and environment condition in Kendari waters are better than the some waters.

Further analysis showed that the length at first capture (L_c) of blue swimming crab in the Kendari Bay was smaller than the length at first maturity (L_m). This condition is unexpectable in term of fisheries management. It was recommended that L_m value was larger than L_c value. If this condition is left for long period, the stock of BSC in Kendari Bay would continue to decrease until a level in which the BSC stock will be disrupted and finally no more BSC stock available in the waters enough as a fishery resource. In contrast, if L_c is higher than L_m, it means that the individuals of crab have changes to spawn to maintain its population. In order to ensure the sustainability of the resources, the fishing pattern should allow a number of crabs brood stock to escape (Sudjastani, 1974). To prevent stock degradation in the Kendari Bay, a regulation for net mesh size is needed in catching of blue swimming crabs.

Sparre & Venema (1992) stated that growth is basically the determination of body size as a function of age. Therefore, all the stock assessment methods work based on age composition data. A number of numeric methods in trophic species have been developed for the conversion length frequency data to age composition. Current analysis shows that the blue swimming crab growth rate (K) in the Kendari Bay waters was 0.91 per year and the maximum carapace width (Loo) was 182 mm. The value of K in the Kendari Bay waters is comparable to that of 0.98 per year found in the Persian Gulf(Kamrani *et al.,* 2010). However, the K value obtainned in this study is lower than values of 1.08 – 2.75 reported 1.7 per year from waters of Pakistani, Omani, Thailand, Bone, and Pati (Afzaal *et al.,* 2016; Mehanna *et al.*, 2013; Kunsook *et al*., 2014; Kembaren & Ernawati, 2012; Ernawati *et al*., 2015). The difference of K value in some waters is caused by the avability of food and environment condition (Sparre & Venema, 1998).

Meanwhile, the maximum carapace width ($L\infty$) for BSC in the Kendari Bay (182 mm) was smaller than the maximum carapace width ($L\infty$) that was observed in Pati (187 mm) (Ernawati *et al*., 2015), but larger than the waters of the Persian Gulf, Paskitani, Oman, Thailand, and Bone (102.83 – 178.5 mm) (Kamrani *et al.,* 2010; Afzaal *et al.,* 2016; Kunsook *et al*., 2014; Kembaren & Ernawati, 2012). Aziz *et al*. (1989) stated that the different growth parameters were caused by different factors, such as: time, season, fish size, fishing equipment, and fishing grounds during sampling. Herianti & Rachman (1993) stated that growth is not only influenced by the conditions in the environment where the fish live, but is also influenced by some factors while their parents' are alive, which affect the yolk supply, fat content, and growth rate of the young produced. Heupel *et al.* (2009) added that the L infinity (Loo) difference is due genetic variation, water environment, fishing equipment selectivity, and differences in habitat.

In the blue swimming crab fishery developed in the Kendari Bay, the total mortality rate (Z) is a combination between the natural mortality rate (M) and fishing mortality rate (F) (Sparre & Venema, 1992). The value of M for blue swimming crab in the Kendari Bay was smaller than F value, demonstrated by the death of most blue swimming crabs in the Kendari Bay during capture. Furthermore, using the value of F reflecting the fishing pressure and Z describing the total mortality, the result of the exploitation rate (E) for blue swimming crab was 0.73 per year. If compared to the criteria of Pauly *et al*. (1984), stating that the optimum utilization rate is 0.5, the utilization rate of blue swimming crab in the Kendari Bay has exceeded the optimum rate. This shows that the blue swimming crab utilization rate has reached 146%, which is already within the overfishing category. So that, to maintain the sustainability of BSC resources in the Kendari Bay, a management measure is needed to decrease the fishing effort of approximately 46% of the current effort.

CONCLUSION

The growth pattern of blue swimming crab in Kendari Bay and surrounding waters is balance for both carapace width and weight. The length at first capture (L_c) which is smaller than the length at first maturity (L_m) may disturb BSC resource sustainability. The blue swimming crab growth rate and the mortality rate were classified as high. The exploitation rate of BSC resources in Kendari Bay was already classified as overfishing category. To ensure the waters sustainability, regulated on the net mesh size and a reduction of approximately 46 % of the current fishing effort is advisable. For determining of the net mesh size, it is still needed further research in this waters. In addition, an assessment of the socio-economic aspect may result to a more accurate stock status of BSC in Kendari Bay.

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